N94-16183

THE FORMATION AND EVOLUTION OF ALPHA AND TELLUS TESSERAE ON VENUS:

M. S. Gilmore and J. W. Head, Department of Geological Sciences, Brown University, Providence, RI 02912.

Although tesserae comprise ≈10% of the surface of Venus, the nature of their formation and evolution is not well understood [1]. One important clue to elucidate this problem is tessera boundaries which are of two types: Type 1 are generally embayed by plains; Type II boundaries are characterized by being linear at the hundred kilometer scale and often associated with steep scarps or tectonic features [2,3]. Previous study of a distinctive Type II boundary at Alpha Regio [4] was pursued in order to characterize and assess the implications for this style in general. A model of gravitational relaxation of the tessera block was presented to explain the specific style of Type II feature seen at western Alpha [4]; however, this model cannot account for the full range of interior structures of Alpha, namely widespread compressional features overprinted by extensional features and volcanism. In order to explain the features of Alpha we have considered a three-stage model involving 1) mantle downwelling and compression of the lithosphere 2) delamination of the thickened tessera root and 3) gravitational relaxation and extension of the tessera plateau. We compare this to the characteristics of Tellus Regio in order to test its broader application.

Alpha Regio. The western (Type II) boundary of Alpha Regio contains ridges and troughs that trend northeast and extend into the adjoining plains. These are joined by a second set of extensional features that extend northwest from the tessera into the plains for several hundred kilometers. The number and spacing of these lineaments were used to define six plains units west of Alpha; the most deformed plains units were almost indistinguishable from tessera. Additionally, the tessera along western Alpha contains numerous domes, pits, and small shield volcanoes that are very similar to the array of shield volcanoes that have been mapped on the Venus plains [5]. The fractured plains units and domes are the primary clues that western Alpha Regio may consist of plains that are sequentially deformed, tilted, and uplifted, ultimately being incorporated into the tessera.

Inter-tessera plains (ITP) in Alpha comprise approximately 10% of its surface area. They range in size from 20 -200 km in length and may contain several episodes of volcanism, the oldest of which has suffered some regional deformation in many cases. The ITP are elongate to circular in shape, and most have associated concentric ridges and scarps. Small shields and fissures are also present in many of the ITP. In Alpha, no volcanism in the interior of the tessera exists outside the ITP.

Tellus Regio. Type II boundaries comprise 34% of the boundary of Tellus [6]. Six hundred kilometers of the northeast border of Tellus has features similar to the western boundary of Alpha. Large graben up to 10 km in width extend NE from the interior of Tellus into the adjoining plains unit. Many of these graben contain pit craters and seem to originate from within inter-tessera plains 200 km into the tessera. The edge of the tessera contains small domes and pits that predate and postdate graben formation. Two plains units can be distinguished, the southernmost of which has more fractures than the northern. The extensional deformation at this Type II boundary of Tellus seems to incorporate plains lavas.

Inter-tessera plains comprise perhaps up to 15% of the surface of Tellus, but this is difficult to constrain as the northern part of Tellus has been flooded by a combination of interior and exterior plains lavas. Individual ITP may range from 25 - 200 km in length and several ITP are connected into systems as large as 400 X 100 km. The ITP in Tellus are generally more rounded than those in Alpha, having a circular to oval shape. They are surrounded by concentric ridges and may also have extensional features perpendicular to their borders. Like Alpha, these plains display multiple episodes of volcanism, domes and fissures, and regional extensional features in their older flow units. Volcanism is not confined to the ITP in Tellus, however, it extends in many places to flood the graben and extensional features that are dominant in this tessera block. Plains units have encroached into the interior of Tellus; this may be due to the fact that the base of Tellus (planetary radius of 6052 km) is at a lower elevation than Alpha (6052.5 km) [7].

Models proposed to explain the characteristics at Alpha and Tellus must be consistent with several other features of both tessera: 1) the earliest deformation of the tessera block was compressional, characterized by complex thrust and strike-slip faulting; these compressional features are overprinted by later graben and extensional faults [2]; 2) the presence of mostly undeformed inter-tessera plains up to 200 km in length; 3) the lineaments at western Alpha and northeastern Tellus have occurred relatively recently in the history of the plateau as they cross-cut all other features both in the tessera and in the plains; 4) in general, Type II boundaries do not extend over the entire margin of the tessera block.

Although both upwelling [8] and downwelling [7] have been proposed, mantle downwelling is becoming a preferable mechanism for the formation of tessera on Venus [9,10]. Downwelling would produce a topographic low initially, followed by convergence and subsequent thickening of the crust; uplift would continue until the crustal block isostatically compensates [9]. This can easily produce the compressional features seen in tessera but cannot explain as well the interior volcanism and graben.

During convergence, the mantle portion of the lithosphere should thicken along with the crust, protruding into the warmer asthenosphere [11]. This is gravitationally unstable as the mantle portion of the lithosphere is more dense than the asthenosphere below it [12]. Downward convection could delaminate the unstable upper mantle most likely at the crust-mantle boundary [11,12]. Hot asthenosphere would rise replacing the lost lithosphere, pooling at the base of the crust. This asthenosphere would undergo partial melting by adiabatic decompression and may also melt crustal material. Extension would occur because of the added heat allowing dikes to propagate perhaps to the surface or collecting in magma chambers in the upper crust. These magma chambers could then be the source for the inter-tessera plains which contain domes and small shield volcanoes as well as fissures. The rounded shape of the ITP, especially in Tellus Regio, is consistent with their being sites of diapiric upwellings of magma. The inter-tessera plains have multiple flow units; the oldest unit in the sequence is frequently overprinted with regional extensional features. This is consistent with ongoing extension and volcanism being the latest stages in tessera evolution.

As the hot mantle beneath the tesserae reequilibrates, the tessera block will subside due to gravitational relaxation which is favored under Venus conditions of high temperature and low erosion rates [13,14]. Volcanism and extensional features will become more widespread within the interior of the block. Indeed, Tellus Regio may represent this stage of tessera evolution. Compared to Alpha Regio, Tellus has more pervasive lava units within inter-tessera plains and filling most of the graben within the tessera block. Extensional features are so dominant in Tellus that few compressional structures are observable [7]. Lavas from the plains units adjacent to Tellus embay most of its boundary and have encroached upon the interior of the tessera.

Summary. Downwelling caused by mantle convection or instabilities in a depleted mantle layer could cause compression and thickening of the crust [9]. This compression would result in the thrust and strike-slip faulting seen at the surface of the tesserae [2]. Cessation of this downwelling may produce the late-stage extensional features and volcanism of Alpha and Tellus; this may be caused by a delamination event in the mantle portion of the lithosphere or along the basalt-eclogite transition in the thickened crustal root. The tessera block could then isostatically compensate and reequilibrate, and eventually gravitational relaxation becomes dominant. This relaxation is expected to produce deformation perpendicular to topographical slope at the edges of the tessera block [14]; as this relaxation continues, deformation would spread outward from the tessera into the surrounding plains.

REFERENCES: [1] Basilevsky, A. T., *et al.*. (1986) *J. Geophys. Res.*, *91*, D399. [2] Bindshadler, D. L., and Head, J. W. (1991) *J. Geophys. Res.*, *96*, 5889. [3] Ivanov, M. A., *et al.*. (1992) *LPSC XXIII*, 581. [4] Gilmore, M. S., and Head, J. W. (1992) *Abs. Int. Colloq. Venus* . [5] Aubele, J. *et al.*. (1992) *LPSC XXIII*, 47. [6] Ivanov, M. A., and Head, J. W. (1993) this volume. [7] Bindshadler, D. L. *et al.*. (1992) *J. Geophys. Res.*, *97*, 13495. [8] Philips, R. J., *et al* . (1991) *Science*, *252*, 651. [9] Bindshadler, D. L., and Parmentier, E. M. (1990) *J. Geophys. Res.*, *95*, 21329. [10] Bindshadler, D. L. *et al.*. (1992) *J. Geophys. Res.*, *97*, 13563. [11] Loosveld, R. J. H., and Etheridge, M. A. (1990) *J. Metamorph. Geo.*, *8*, 257. [12] Bird, P. B. (1979) *J. Geophys. Res.*, *84*, 7561. [13] Weertman, J. (1979) *Phys. Earth. Plan. Int.*, *19*, 197. [14] Smrekar, S. E., and Solomon S. C. (1992) *J. Geophys. Res.*, *97*, 16121.